U.S. EPA STAR NATIONAL CENTERS FOR INNOVATION IN SMALL DRINKING WATER SYSTEMS

Design of Risk Reducing, Innovative Implementable Small System Knowledge (DeRISK) Center Status Update

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www.colorado.edu/deriskcenter
U.S. EPA Request for Assistance

Center’s mission to:

identify, develop, demonstrate and facilitate widespread acceptance and applicability of novel and innovative technologies and approaches to measure or treat groups of microbiological or chemical contaminants, or their precursors;

apply novel new information technology systems; and

improve the sustainability of small drinking water systems.
Research Team

- University of Colorado Boulder (UC-B)
  - R. Scott Summers (PI), Karl Linden (CoPI), Chad Seidel (Co-Director), Fernando Rosario, Sherri Cook, Chris Corwin, Jim Uber and Erin Printy (center manager)

- University of New Hampshire (UNH)
  - Robin Collins (CoPI) and Jim Malley (CoPI)

- Rural Community Assistance Partnership (RCAP)
  - Joy Barrett, Bill Hogrewe, Jeff Oxenford, Pablo Cornejo

- University of Alaska – Anchorage (UA-A)
  - Aaron Dotson

- Arizona State University (ASU),
  - Kiril Hristovski and Paul Westerhoff
Approach

Through the utilization of a new cumulative risk assessment methodology, the Relative Health Indicator (RHI), we have identified

- two contaminant groups:
  - pathogenic microorganisms – acute risk
  - disinfection by-products (DBPs) – chronic risk
- one inorganic compound:
  - nitrate

which collectively pose the greatest risk to drinking water consumers.
Approach

Innovative technology selection criteria:

a) potential to provide quantifiable risk reduction in these key contaminant groups
b) lack of required chemical addition
c) likelihood of being successfully implemented and sustained by small systems
DeRISK Center Project 1

*Help utilities, states, consultants, technology providers make technology decisions based on actual public health protection and sustainability, not just regulatory compliance*

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**Risk**

**Sustainability**

Jim Malley, CoPI
Chad Seidel, Technical Director
DeRISK Center Project 1

Develop and apply

1) a relative risk-based index, RHI, to evaluate how treatment decisions impact overall risk reduction and avoidance

2) a sustainability index in order to comprehensively evaluate treatment technologies

3) a methodology to evaluate systems and technologies with the purpose of determining if an innovative technology is feasible, appropriate and implementable for a specific small system’s needs

4) a training design support tool

Case study – utilize above assessment approach and implement innovative polychromatic UV technologies

Evaluate a regional alliance strategy for very remote rural communities
Risk Index

Develop and apply a relative risk-based index, Relative Health Indicator (RHI), to evaluate how treatment decisions impact overall risk reduction and avoidance.

Approach

- Understand how various treatment processes impact delivered water quality
- Assess health risks associated with these delivered water qualities
- Compare individual and total RHI estimates by treatment process and source water to prioritize most effective solutions

Chad Seidel, Technical Director and John Meyer, MS student
Relative Health Indicator (RHI) metric allows for comparison of “cups of risk” among finished drinking waters.
Risk Modeling Approach

Source Water → Baseline Treatment Train → Compliance Strategy 1 → Compliance Strategy 2 → Compliance Strategy 3 → Treatment Model Application → Baseline Finished Water Quality Profile → RHI Application → Baseline Risk Index

- Baseline Risk Index
- Risk Index 1
- Risk Index 2
- Risk Index 3
1) Predict DBP concentrations for baseline treatment trains using the USEPA Water Treatment Plant (WTP) Model

2) Model alternative DBP control and removal techniques using predictive algorithms based on existing treatment models and regulatory MCLs

3) Apply RHI methodology to quantify risk for baseline and alternative treatments

4) Normalize the relative risk reductions to population distributions and cost to determine which are the most efficient solutions under different scenarios
Demonstration of Treatment DBP Risk Assessment

1. Baseline
2. Enhanced Coagulation
3. Distribution System Aeration
4. Distribution System GAC
DBP Risk Comparison

Risk Profile Comparison

- **Baseline**
- **DS Aeration**
- **DS GAC**
- **Optimized Coagulation**
- **End Of System**

DeRISK Center
DBP Risk Comparison

Compliance Strategy DBP Risk Comparison

- **Baseline**
- **Optimized Coagulation**
- **DS Aeration**
- **DS GAC**

**RHI**

- **Maximum**
- **Average**
Sustainability Index: Life cycle assessment methodology to quantify the impacts of four disinfection systems

- LCI inputs
  - raw materials
  - energy

- Disinfection system
  - unit process #1
  - unit process #2
  - unit process #3
  - unit process #4
  - unit process #5

- LCI outputs
  - air emissions
  - water emissions
  - soil emissions

- LCIA outputs
  - emission categories
    - respiratory effects
    - global warming
    - smog
    - ozone depletion
    - acidification
    - carcinogens
    - non-carcinogens
    - ecotoxicity
    - eutrophication
    - fossil fuel depletion

- goal definition & scoping
  - inventory
  - impact
  - interpretation
  - classify & characterize

Prof. Sherri Cook and Lizzy Shilling, Topher Jones MS students
LCA outputs are characterized by their relative contribution to impacts

- Respiratory effects
- Non carcinogenics
- Ozone depletion
- Carcinogenics
- Smog
- Ecotoxicity
- Acidification
- Eutrophication
- Global warming
- Fossil fuel depletion

Human health:
- Ecosystem quality

Resources:
- Climate change
Four disinfection technology systems were evaluated.

Chlorine - Concrete Basin

Chlorine – Plastic Basin

Ultraviolet Low Pressure (LP-UV)

Ultraviolet Medium Pressure (MP-UV)
Decision Support Methodology

Develop and apply a methodology to evaluate systems and technologies with the purpose of determining if an innovative technology is feasible, appropriate and implementable for a specific small system’s needs

Approach

- Develop multi-criteria decision-support methodology
- Create a data system for innovative treatment technology information
- Disseminate information and promote use by small system technical assistance providers
Identify Feasible Alternatives → Evaluate Alternatives → Recommended Alternative

Characteristics of Innovative & Conventional Technologies → Health Risk Analysis

Stakeholder Preferences → Sustainability Analysis

Feasible alternatives → Performance information

Decision Support Methodology Hogrewe et al.

“Improving the quality of life in rural communities”
UV Case Studies

Develop and implement polychromatic UV technologies for virus inactivation

- HAWC, Kingston, NH
- Bethlehem, NH
- Underway at STAR Island, Rye, NH
- Hillsborough Full-scale in operation since 2014
Regional Alliance Strategies

- Utilize existing databases to identify technological linkages between existing utilities in Alaska
Project 2: Photon-based Treatment

- shallow pretreatment basins for disinfection efficiency and control of DBP formation
- field-test small-system sized UV - LED disinfection module containing UV - LEDs of varying wavelengths
- photocatalytic reduction of nitrate in IX brines
- innovative UV-membrane hybrid process

Project 3: Extended Biofiltration

- novel roughing filter pretreatment configurations
- innovative filter modifications and operations of existing filters to extend EBCT and improve performance

Project 4: Distribution System Technologies

- horizontal diffused aeration system to remove THMs
- GAC in the distribution system to adsorb and biodegrade preformed DBPs and DBP precursors
- real-time analytics and protocols to better manage distribution system resources - residence times, chlorine residuals, non-revenue losses and pipe break detections
Snapshots

UV-membrane hybrid, Dotson et al, UAA

HILDA/VILDA
Collins et al, UNH

Uber and Hatchett
Outcomes

- A field-tested multi-criteria decision support approach that will allow utilities and state agencies to
  a) limit the inappropriate use of technologies and reduce institutional barriers to use of appropriate technologies
  b) increase regulatory compliance and reduce risk associated with regulated and some unregulated contaminants
  c) make decisions based on an actionable sustainability index
  d) share information and provide training on new technologies

- Innovative and sustainable technologies for small systems that will increase public health protection
Information Resources

- DeRISK: www.colorado.edu/deriskcenter
- WINSSS: www.umass.edu/winssss
- Joint Newsletter: www.smallwatersupply.org
  Subscribe to the “Technology News” newsletter...
- Joint Website: www.drinkingwatercenters.org
  Coming soon...
Next Steps…

- Translate outcomes into practice with
  - States
  - Utilities
  - Consultants
  - Technology providers

- We welcome the opportunity to put the approach and tools to work to help you!
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